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Towards 'green growth': Measuring the trade-off between conservation of protected areas and hydel power generation in an ecologically fragile hill state of Northern India

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Towards 'green growth': Measuring the trade-off between conservation of protected areas and hydel power generation in an ecologically fragile hill state of Northern India[1]

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Abstract

The State of Himachal Pradesh in India has initiated a number of projects to tap its hydro-power potential, some of which will submerge parts of sanctuaries. In a bid to move towards 'green growth' which protects ecologically critical areas, we examine two hydel-power plants, in which reservoirs will submerge sanctuaries/protected areas, to measure the costs and benefits to the state should these plants not be undertaken. We measure impacts on the industrial and tourism sectors of the state (which account for 60% of the state's total domestic electricity consumption) and measure the loss in value added due to reduced supply of electricity. The gain to the state is by way of tourism income and ecosystem services due to conservation of sanctuaries. We estimate production functions and use standard regression analysis to determine the value of the two effects over the time period 2012 to 2030. The gain from preservation calculates to about INR133.25 million, but the industrial value added decreases by INR202.9973 million and the cost of going green comes about INR49.14 million for the year 2012 and about INR67.46 million by 2030. However, it constitutes a negligible 0.0045 to 0.0038 percent of the State's projected net domestic product. The figure would be further lowered if we consider equity issues or assume the demand for tourism and ecosystem services to grow faster than developmental benefits with wellbeing.

Key word: Green growth, Hydel Power, Sanctuaries, Cost of conservation, Hilly ecosystem, Himachal Pradesh

JEL Classification: Q01, Q57

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[1] This paper is built on work done as part of a report submitted to the World Bank, New Delhi entitled **India Environmental Outlook 2030: Opportunities for growth in the ecologically fragile hill states: a study of Himachal Pradesh April 2010**

Towards 'green growth': Measuring the trade-off between conservation of protected areas and hydel power generation in an ecologically fragile hill state of Northern India

1. Introduction

In a developing country like India, there exists, at the present point of time an almost exclusive focus on growth with industrialisation. Under a business-as-usual scenario this is likely to generate substantial environmental degradation and a surging demand for scarce resources needed to fuel growth and sustain life supporting environmental systems. Environmental sustainability may become the next major development challenge as the country surges along its growth path. This concern, in particular, will be true for ecologically fragile hilly regions of the country, like Himachal Pradesh where many developmental projects have been initiated. Given the current focus on 'green growth' strategy (World Bank 2012; UNEP 2008; OECD 2011; GGGI 2010), the paper tries to explore the synergies and trade-offs if two hydel power projects are dropped in order to conserve some of the fragile and ecologically important ecosystems of the state.

Green growth in a long term perspective is growth without unsustainable deterioration of the environment or growth with "modest" negative impacts on the environment in the short term (Smulders and Withagen, 2011). Hydel power comes under green energy, but generation of hydro power does have strong environmental impacts, especially the ones based on reservoir projects. Green growth strategy defines growth process to be resource efficient, cleaner and more resilient without slowing down the growth and operationalising it requires (i) identification of channels through which green policies can contribute to growth, (ii) identification of synergies between development and protection or presence of any sub-optimalities in growth process, (iii) identification of future impacts to avoid unsustainable or expensive production patterns etc (Hallegatte et al. 2011; Hogarth and Kunreuther, 1995; Tversky and Shafir, 1992). Estimation of short run cost of going green and identification of synergies between green policy and beneficiary sectors can help pursue a more efficient growth path that utilizes the synergies. The paper tries to address such points in order to pursue a more sustainable growth model based on hydel power generation for the state of Himachal Pradesh. We measure the expected impacts of some reduction in power supply on industrial and tourism sectors of the state as (i) these two sectors use substantial part of the domestic power and therefore the policy impact will be high on these sectors, and (ii) there was some time series data available on these sectors to conduct empirical analyses. We find the synergies between conservation and tourism quite strong and the cost of remaining green not so high for the state on the basis of this partial analysis. We set up alternative scenarios[2] and examine the projected situation from 2012 through 2030 using some quantitative techniques.

[2] "Scenarios are plausible, provocative and relevant stories about how the future might unfold. They can be told in both words and numbers. Scenarios are not forecasts, projections or recommendations, though model projections may be used to quantify some aspects of the scenarios" (Millennium Ecosystem Assessment, (2005) Volume 2, Findings of the scenarios working Group.

First we start with an insight into the nature of resource base in Himachal Pradesh in 2009 and expected changes in it up to 2030 in section 2. Section 3 gives an overview of the sectoral linkages of hydro-power generation; section 4 discusses the methodological overview for the scenario exercise and in later sections, estimation of the models, the results and the conclusion with a few issues for discussion are presented.

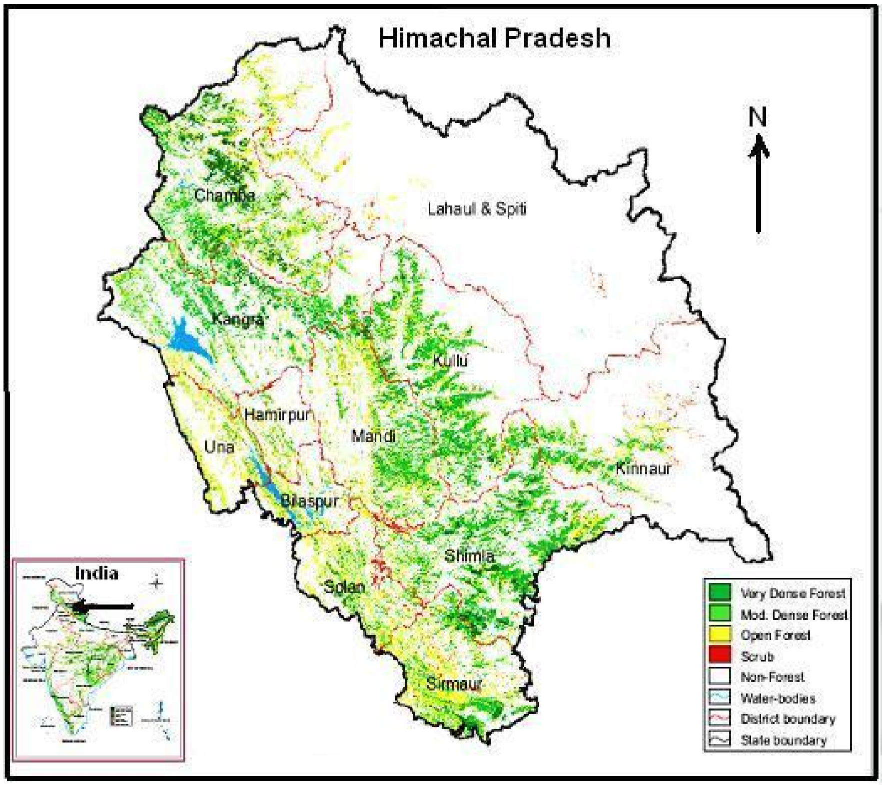
2. The Resource Base of Himachal Pradesh

Himachal Pradesh, situated between 30^o 22' 40" to 33^o 12’ 20" north latitudes and 75^o 45' 55" to 79^o 04’ 20" east longitudes is a wholly mountainous region in the lap of Himalayas and its altitude ranges from 350 meters to 6975 meters above mean sea level. Based on altitudes and moisture conditions, the state can be divided into five zones like wet humid sub-temperate situation to dry temperate alpine high lands. The rate of growth of the State economy remained generally lower than the national average during the first 35 years of India’s planned development (1950 to 1985), though it has been reversed from the Seventh Five Year Plan (1985-90) onwards. During the Tenth Plan (2002-07), the primary sector is expected to achieve an average annual growth rate of 8.5% against its original target of 4.5%. Annual growth rates of the secondary and tertiary sectors are expected as 7.42% and 7.53% which are significant compared to the national averages. Given its record of development, the state is well-positioned to define for itself a future strategy of development which is rooted in its natural resource base and ensures future prosperity of its people.

2.1 Land and forest resources

The total geographical area of Himachal Pradesh is 55.67 lakh hectares, of which only 5.73 lakh hectares (10.4%) is net sown area under crop agriculture. Further, the net sown area is not likely to increase due to the hilly terrain of the state making the state dependant more on other sectors.

Forest area comprises 67% of the geographical area of the state and constitutes the major resource base of the state’s economy. Moreover, adequate forest cover is essential to minimize problems of floods, soil erosion and for retention of precipitation. Although 67% of the geographical area is legally classified as ‘forest area’, actual tree cover is not possible in this entire area as much of it is above the tree line or incapable of sustaining forests. The goal of the state is to ensure that 35.5 percent of the total geographical area of the state is brought under forest and tree cover and the balance ‘forest area’ be managed as alpine pastures, snow peaks and water bodies, glaciers, etc. Figure 1 shows the forest cover of the state over different districts.



Source: Dr. Hemant Gupta, Forest Survey of India, Simla, Himachal Pradesh

Figure 1: Forest cover map of Himachal Pradesh

The state has 7002 sq kms of forest area under protected areas, with two major national parks covering 1440 sq kms and 33 wild life sanctuaries covering 5562 sq kms. The national parks are in Kullu and in Lahaul-Spiti, whereas the wild life sanctuaries are spread over a large number of districts. Appendix Table A1 gives the location, the forest division and area of the protected areas in the state.

However, all is not well with the forest cover of the state. It is understood that in 2008, the Himachal government sought the de-notification of five sanctuaries i.e. Naina devi (Bilaspur), Shikari devi (Mandi), Gobindsagar (Bilaspur), Shili and Darlaghat (Solan) and studies have shown that the quality of forest cover in the state to be deteriorating (Gupta, 2006). Considering the significance of these protected areas as sources of tourism, rural livelihoods and consumption and as a repository of biodiversity and culture of the region, this is a major concern.

2.2 Water Resources and Hydropower potential

The drainage system of Himachal Pradesh is composed of Himalayan Rivers. Rivers from two river systems- Indus River System (Sutlej, the Beas, the Ravi, the Chenab and the Jhelum) and Ganga River System (only river Yamuna) flow through the state, the former constituting 90% of the drainage system. The Yamuna with its tributaries flows in the eastern part of the state while the Satluj valley traverses the state and this river has the largest catchment in the state. In addition, several natural lakes are to be found, which comprises the upper catchment for various services provided to different other states. Among these is the hydro electric potential which is currently the focus of development. In Himachal Pradesh, as elsewhere, power is one of the main drivers of growth of different sectors including tourism and industry. Power is also envisaged to be exported to support growth in the rest of India. This is particularly significant because India as a whole is challenged by the need to tap all available sources of power. Since Himachal Pradesh has a huge hydel power potential, in particular in the upper reaches of its rivers, its exploitation for providing power can be viewed as a driver of growth in the state, and also a component of power development in the country as a whole. Given the focus on renewable sources of power, HP is positioned to play an important role in this strategy, since it has tapped only 20% of its potential of 20,000 MW.

A comparative overview with regard to hydropower potential of various river basins in the state has been presented below in Table 2.1. The total potential of various river basins in terms of power generation is estimated to be 20463.5 MW approx. As of 2008, Himachal Pradesh had 145 Hydro Electric projects worth Rs474.79 billion in various stages of planning and implementation.

Table 2.1
Hydropower potential in various River Basins of Himachal Pradesh

River Basin	**Identified potential MW**
Satluj	9728.25
Beas	4293
Ravi	2181
Chenab	3301
Yamuna	960
Total	**20,464**

Source: Environmental Impact Assessment for Rampur Hydro Electric Project, Himachal Pradesh, 2005

The river Satluj has the largest identified potential and several projects of run-of-river and other kinds are being planned. Detailed estimates of hydel power projects likely to be operational in different private, central and state schemes in Himachal Pradesh by 2012 are available[3]. As thermal power has been placed in the negative list, almost all the power development is planned to be in the hydel sector, with a capacity of 15436 MW of the identified potential of 20386 MW to be reached by 2012. This includes presently operational projects and those under execution and expected to be completed by 2012. The table 2.2 shows the position before and after 2012 and table 2.3, the details of various projects under execution. As seen from table 2.3, except Renuka and Koeldam, the rest of the projects are run-of-river types that are supposed to be causing less environmental stress including less deforestation.

Table 2.2
Summary of HP Power Situation

Detail of Position before 2012	
Harnessed so far	6067 MW
Under Execution	7602 MW
Advertised by October 2005	1767 MW

[3] See Planning Commission, Government of India, Himachal Pradesh Development Report. Also see HP Government Official Website, Department of Power and others.

Completed by 2012 **15,436 MW**
Balance Potential (including Himurja) likely to be harnessed by 2024 4950 MW

Source: *Himachal Pradesh Development Report, 2005, Planning Commission, Government of India, Delhi.*

Table 2.3
Details of Power Projects under execution in HP

River Basin	Name of Project	Capacity (MW)	Type	Category
River Yamuna Basin				
1	Sainj	5.5	ROR	B
2	Dhamwari Sunda	70	ROR	A
3	Renuka Dam	40	Reservoir	A
River Satluj Basin				
1	Bhaba Aug P/House	3	ROR	B
2	Nathpa Jhakri	1500	ROR	A
3	Baspa Stage II	300	ROR	A
4	Karchham Wangtoo	1000	ROR	A
5	Koldam	800	Reservoir	A
6	Keshang Stage - 1	66	ROR	A
River Beas Basin				
1	Larji	126	ROR	A
2	Khauli	12	ROR	B
3	Parbati Stage II	2051	ROR	A
4	Neogal	15	ROR	B
5	Allian Dhugan	192	ROR	A
6	Patkari	16	ROR	B
7	Fozal	6	ROR	B
8	Uhl Stage III	100	ROR	A
River Ravi Basin				
1	Holi	3	ROR	B
2	Chamera Stage II	300	ROR	A
3	Chamera Stage II	231	ROR	A
4	Bharmour	45	ROR	A
5	Budhil	70	ROR	A
6	Harsar	60	ROR	A
7	Kugti	45	ROR	A
8	Mini Micro(upto 3MW)	101.59		
Total of under Execution = 7059.14				
Forest land submerged per MW of power under **1. Run-Of-River (ROR) project: 0.114 ha** **2. Reservoir project: 5.52 ha** **Note: A, B, C are rankings of power projects as per its attractiveness as prepared by Central Electricity Authority of India**				

Current availability of power in Himachal Pradesh is from own generation, purchase from other generators and from free power from central, joint and private sector hydro power companies in the state[4]. Demand forecasts indicate that the state will be self-sufficient in power by 2015-16 if output increases as planned. [5] However, there is continuing controversy with regard to the impact of these multiple projects on the ecosystems, the riverine species, and the landscape and complaints are being filed before the judiciary, UNFCCC etc. These effects need to be viewed in the context of the benefits to the economy of the state and the country.

3. Hydel-Power: Sectoral linkages

3.1 Hydel Power- Environment -Forest Ecosystem Services: Interactions and Environmental Costs

Hydel power is projected as 'green energy'. However, the debate on its environmental costs continues and several externalities of hydel power projects have been pointed out in the literature (Koch, 2001; http:\\www.ieahydro.org). Forest land being diverted or lost has been one of the important externalities most often pointed out. The argument is couched in terms of reservoir based as against run-of-the river projects. Reservoir based projects have attracted worldwide attention in this regard. Both kinds of projects result in conversion of forest land to non-forest use, though the magnitude is smaller in the case of run-of–the–river (R-O-R) projects. From studies carried out on the two kinds of projects, some approximations of area converted in the two cases for each MW of power capacity are obtained. It is estimated that for each unit of power produced, forest area converted/ submerged is, on average, 5.52 hectares for reservoir based projects and 0.114 hectares for R-O-R projects (TERI, 2008). However, run-of the river projects, in particular multiple ones on a particular river change the ecology of the region too and loss of forests due to submergence is not the only environmental cost. One of the recent research shows the catastrophic effect on fish productivity and biodiversity because of multiple hydro power dams on the Mekong river basin (Ziv et al., 2012). The multiple projects that are being planned in the upper reaches of the rivers in HP (such as for example Sutlej and Ravi and Beas in Kinnaur, and Mandi) will result in tunnelling of rivers over long stretches. Riverine ecosystem services will be impacted. Further, in the context of R-O-R projects, major disturbances are also due to construction, migration and the cost of disposal of muck.

Resettlement and rehabilitation of affected human populations is again a factor linked to reservoir based projects only. There are processes in place for this and it is expected that these will be followed. Only case studies can verify to what extent it is being done.

3.1.1 Valuing forest ecosystem services lost: partial and conditional

Forest ecosystems provide a range of services, well documented in the literature now (Millennium Ecosystem Assessment, 2006). However, valuing these services lost due to conversion of forest land to non-forest uses needs to use a carefully nuanced methodology which:

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[4] As per agreement, power companies are to provide some percentage of power generated as free power to host states.

[5] See Planning Commission (Government of India) HP development report, Chapter on Infrastructure. Issues of peak load shortages may still remain as per communication from HP government officials. For that the HP is investing in a coal-based project outside the state so that it can claim a part of its output when need be.

- Captures variations that occur because of ecological aspects of forests.
- Takes into account sustainability concerns regarding extraction from forests.
- Considers aggregation issues in valuing ecosystem services.
- Incorporates concerns about biodiversity valuation, particularly in protected areas.
- Adopts a multidisciplinary approach to valuation and recognises the relevance of using more than one policy instrument for managing forest ecosystems.

A step by step methodology incorporating some of the above points to obtain estimates for Himachal Pradesh has been developed by Chopra and Dasgupta (2008). The net present value of the loss of forest ecosystem services in areas other than protected areas is estimated to be INR 4.91 billion for the year 2009. This amounts to an annual value of INR 0.32 billion over the period 2009 to 2030.[6] We consider this to be an important cost of forest conversion to hydel power projects and this cost is much higher if protected areas are being submerged.

3.2 Hydel power – Industry – Tourism: Linkages

Other than the cost on environment and loss of ecosystem services, the hydel power generation has important other inter-sector linkages that influences the net impact on well being of people. We express these linkages for the industry and tourism sectors which are more power dependant in Himachal Pradesh with the help of a flow chart in Fig 2. Of the total electricity consumed in the state, the industrial sector accounts for more than 50% and the tourism sector (trade, hotel and restaurant sector) more than 7% and thus, both account for nearly 60% of the domestic power use in the state (Planning Department, Himachal Pradesh, 2006).

Generation of hydel power has positive feedback on industries whereas it has both positive and negative feedback on tourism sector as power supply adds to tourist inflow by providing facilities and decreases the inflow by converting forests, the biggest tourist attractions to water reservoirs. It also reduces the flow of ecosystem services which is an important source of well being to people, especially those belonging to lower economic strata. The paper tries to quantify these linkages and measures the net impact on the State Net Domestic Product. We take the hypothetical situation of dropping Renuka and Koeldam projects as these two are reservoir based projects and are likely to have high environmental impacts. The next section explains these inter-linkages with the help of equations and then estimates them econometrically.

[6] For details, see report submitted to the office of World Bank, New Delhi on "India Environmental Outlook 2030: Opportunities for growth in the ecologically fragile hill states: a study of Himachal Pradesh" (unpublished).

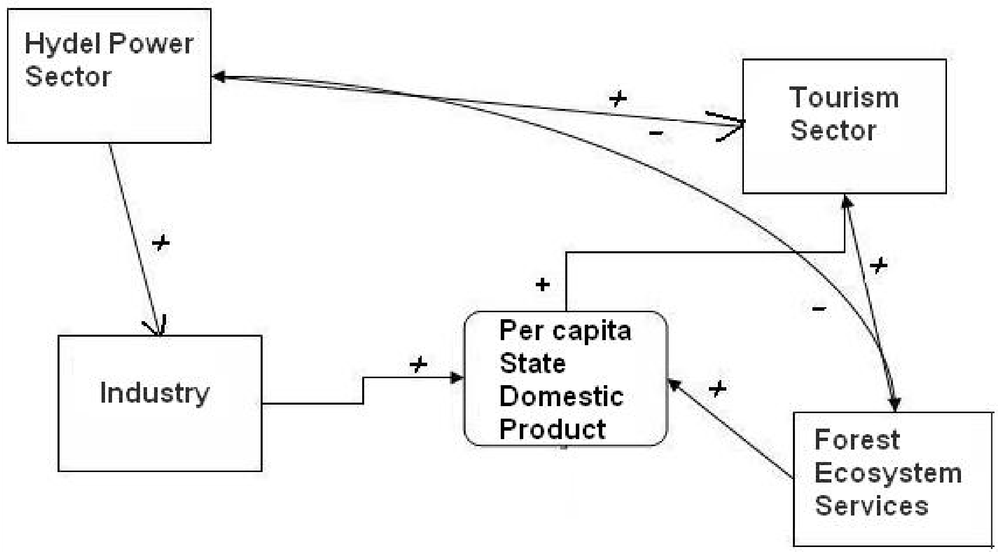

Figure 2: Hydel Power-Tourism-Indusrtries: Intersectoral Linkages

4. The methodology: Sectors and Scenarios

We take three hydro power related sectors, i.e. industries, tourism and forest and measure the change in value added of these sectors due to the decrease in power supply because of the dropping of the two power plants. We define the interrelations with the help of these equations.

$$V_I = f(I,E,P), \quad f_I, f_E, f_P > 0 \tag{1}$$

$$V_T = g(R,P,F), F = q(P), \; g_R, g_P, g_F > 0 \text{ and } \; q_p < 0 \tag{2}$$

$$E_{SS} = s(F) = s(q(P)), \quad s_F > 0 \text{ and } \; s_P = s_q q_P < 0 \tag{3}$$

where V_I is value added from industries, V_T is value added from tourism and E_{SS} is ecosystem services from forests. Equation 1 defines value added from industries as a function of I (investment), E (employment) and P (power) and all marginal products are assumed positive. Equation 2 defines value added from tourism as a function of R (road kilometer), P (power), and F (forest area) with all positive marginal products, but power having a negative impact on tourism by reducing the area under forest cover ($q_p < 0$). Equation 3 defines ecosystem services as a function of forest area where increase in forest area increase the supply of E_{SS} ($s_F>0$), but increase in power supply decreases the services by reducing the forest area ($s_P<0$).

The change in income due to reduced supply of power is defined the following way:

$$\Delta Y_P = \Delta V_{IP} + \Delta V_{TP} + \Delta E_{SSP} = f_P \Delta P + \{g_P \Delta P - g_q q_P \Delta P\} + s_q q_P \Delta P \tag{4}$$

where ΔY_P is change in state domestic product due to change in power supply and the three terms in the right hand side are the changes in income from the three sectors due to ΔP (change in power).
$f_P \Delta P$ is change in value added of industries,
$g_P \Delta P$ is direct effect of power on tourism income,
$g_q q_P \Delta P$ is indirect effect of power on tourism through change in forest area and $s_q q_P \Delta P$ is the change in ecosystem services due to change in forest area because of power projects.

The paper estimates these coefficients from past data and measures these changes in income for industry and tourism sectors for the years 2012 to 2030 and uses the estimates of E_{SS} coefficients from another study done for the study area (Chopra and Dasgupta, 2008).

We set up alternate scenarios which highlight reference and environmentally sustainable paths of development for the sectors, for the time span up to 2030. We present extrapolated sectoral value added under two different scenarios, REFSEN (reference) and SUSDEV (sustainable development).

- The REFSEN (the Reference Scenario) incorporates the impacts of policy changes planned by government as in place in 2009. Significant sectoral parameters are estimated on the basis of data for the period 1980 to 2005 in order to project output for the future. It is important to emphasise that it is not just a business-as usual scenario but takes account of the projected impacts of policies in place in the present.
- The SUSDEV (the Sustainable Development Scenario) examines the sectors for possible environmental effects and their costs and benefits taking the inter-linkages between the industry, power and tourism sectors for identifying output effects of interventions targeted at environmental sustainability.

*4.1 **The REFSEN Scenario: Estimates of Coefficients and Projected Sectoral Outputs***

The reference scenario (REFSEN) assumes that investments will take place as envisaged in current economic policy and outputs will follow the structural relationships inherent in econometric coefficients estimated. We combine manufacturing and construction activities under industry sector as available data on inputs are combined for these activities.

4.1.1 The Manufacturing and Construction Sector

Industrialisation is a relatively recent phenomenon in Himachal Pradesh. Fig 3 and Fig 4 show the trend in industrial employment and investment respectively. In between 1979-80 and 2001-02, the large and medium sector (L&M) grew 8.7 times in size and the small scale sector (SSI) has correspondingly increased 4.7 times. A major set of new incentives for industry was introduced in the state in 2003. These were initially applicable up to March 31, 2009, and then extended to December 31, 2009. The incentives consisted of a set of exemptions and concessions from central and state taxes at different rates and over different periods (http://himachal.nic.in/industry/incpkg.htm). Simultaneously, lists of thrust industries and negative (not to be encouraged) industries have also been drawn up. The thrust areas are: Information Technology, bio-technology and fruit processing etc whereas the negative list contains, among others, thermal power plants, coal washeries, tobacco and tobacco products, organic and inorganic chemicals, cement clinker and asbestos, insecticides and fungicides, marble and minerals, manufacture of pulpwood and pulp etc. Because of climatic and topographical reasons, 95% of the L&M industries are concentrated in just four of the 12 districts of the state i.e. Sirmaur, Solan, Kangra and Una (HP Development Report, 2006).

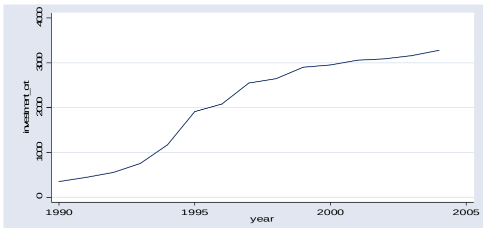

Figure3: Industrial sector Investment

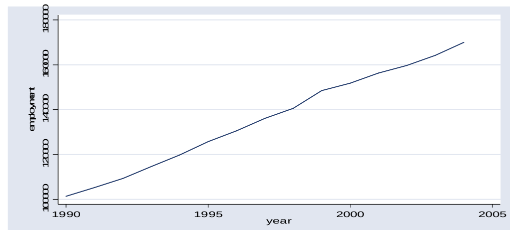

Figure 4: Industrial sector Employment

The period from 2003 to 2009 witnessed an increased pace of industrialisation, partly as a consequence of the incentives provided. This increased pace again was in the same districts as earlier with the addition of Bilaspur as another hub for large and medium industry including two large cement plants. The government policy is indeed to go ahead with industry and to attract as much investment as possible.

In order to capture the relationships underlying industrial production, we estimate a Cobb-Douglas production function for the industrial sector based on data for the period 1980 to 2004. Industry is defined to include both registered and unregistered manufacturing and construction sector. The dependant variable is a measure of value added from these sectors. The factor inputs taken as independent variables are employment, investment and power sold to industrial sector.
The following production function is estimated using data for the period 1980-2004.

$$Y_t = AE_t^{\alpha} I_{t-1}^{\beta} P_t^{\gamma} \qquad (5)$$

where Y = value added from manufacturing + value added from construction,

A is the efficiency parameter, E is employment, I is investment and P is power used.
α, β, and γ are output elasticity of employment, investment and power respectively and t is time period. We expect output to be a function of investment done the previous year.

The constant term came out insignificant and the specification without the constant term gave better results (the value of factor elasticities came less than 1 and all coefficients were significant[7]) and we get the following production function (for details, see the Appendix).

$$Y_t = E_t^{0.54} I_{t-1}^{0.148} P_t^{0.631} \qquad (6)$$

[7] The t values were 6.86, 2.59 and 3.87 respectively.

Next we use extrapolations for employment, investment and power used and predicted output of the industry and manufacturing sector up to 2030.[8] The value added predicted is shown in table 4.2 below. We used a linear extrapolation for investment in spite of a visible concave curve for the past year investments as the various fiscal incentives offered by the state government has been able to draw huge investment to the state and are likely to reverse the down trend.

Note that in making projections of value added from industry, we are assuming:

- that there will be no major technological change,
- that power and investment will not be a constraint on industrial output
- and that earlier patterns of growth will continue up to 2030.

This is reasonably optimistic growth scenarios, which will however have impacts on the quality of the environment.

4.1.2 The Tourism Sector: Arrivals and Output

The tourism industry has flourished in the state of Himachal Pradesh mainly due to its green environment, salubrious climate and facilities provided by the state government. This sector, accounted for in the state accounts under trade, hotels and restaurants, contributes about 8% to the state domestic product but is targeted as a high growth sector, in line with the state's image as a hill state with 33 wild life sanctuaries, 2 national parks and several places of interest to religious tourists. With more facilities becoming available, the tourist inflow has shown a steady growth over the years.

In projecting value added (from the income side) by the tourism sector, our methodology makes it a function of tourist arrivals, direct and indirect income accruing from which is then estimated. To begin with, an econometric exercise is set up to identify the determinants of tourist arrivals in the state. A tourist arrival function is estimated at two levels of aggregation with two sets of data, (i) state as a whole and (ii) at the district level.

At the state level, we postulate that ease of approach, availability of facilities and a generally 'green' environment are the factors determining tourist arrivals. Ease of approach is captured by the variable 'density of road network'; availability of commercial power can be taken to reflect availability of facilities in tourist towns and the variable 'dense forest area' is taken to reflect the attraction of the natural environment for tourists. In other words,

$$\begin{aligned} &Tourist\_arrival\_state = f(dense\_forest\_area, road\_km, \\ &commercial\_power\_used) \end{aligned} \qquad (7)$$

The above equation is estimated using yearly time series data for the period 1980 to 2005.

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[8] See Appendix for detail results and equations used for getting extrapolated values of employment, investment and power used.

Analysis of district level data for a shorter time period is also possible and undertaken. A time series cum cross section pooled data set (for the seven years from 2002 to 2008 and for 12 districts), uses a random effects model to estimate the following equation:

$$Tourist\_arrival\_district = f(dense\_forest\_area, road\_km, religious\_places, sanctuaries\_nature\_parks\_national\_parks) \quad (8)$$

We estimated both the models for arrival of total tourists, Indian tourists and foreign tourists and got interesting results. Religious places of interest to Buddhists and Christians are used in the foreign tourist arrival equation. As the variables are in different units, we are using the **elasticities**, not the simple marginal effects (coefficients) to interpret the results (see table 4.1 (a) and (b)).

Table 4.1 Regression based Elasticity estimates for Tourist Arrivals

Table 4.1 (a) State level estimates

Variables/ Tourists	Total Tourists	Indian tourists	Foreign tourists
Commercial Power	0.511** (2.49)	0.46 (1.57)	1.612*** (4.56)
Kilometres of roads	1.05 ***(2.59)	1.056** (2.38)	1.32 **(2.48)
Dense Forest Area	0.133 (0.31)	-0.187 (-0.44)	0.33 (0.64)
Constant	-10.41* (-1.68)	-7.33 (-1.19)	-24.36*** (-3.31)

Table 4.1 (b) District Level estimates
(Pooled time series cross section data with GLS random Effects Model)

Variables/ Tourists	Total tourists	Indian tourists	Foreign tourists
Kilometres of Roads	0.186 *(1.96)	0.174 *(1.83)	0.553*** (3.01)
Dense Forest Area	0.545* (1.86)	0.566* (1.94)	0.196 (0.47)
Number of Parks and sanctuaries	0.379*(1.88)	0.361* (1.82)	0.879 **(2.29)
No. of. Religious & Tourism Places	-0.102 (-0.36)	-0.120 (-0.42)	0.216 (1.20)

Notes: The figures in parenthesis in both the tables are the t values., **, *** indicate level of significance to be 10, 5 and 1% respectively.*

The state level estimates for equation 8 shows both commercial power and road kilometres to be significantly influencing the tourist arrival. Commercial power captures the facilities in the hotel and road km captures the connectivity to different parts of the state. Though, dense forest area is not significant for the tourist arrival to the state as a whole, it seems to be influencing significantly the tourist arrival in different districts.[9]

The tourism sector in state accounts is included in the sector "trade, hotel and restaurants" and income of this sector, both present and future depends on tourist's arrivals. We predict this income in two steps. In step 1, we predict the future values of dense forest area, commercial power use and road kilometre for the state as a whole using linear trend for the years 2011-12 to 2029-30, the equations themselves came from values of variables for the period 1980 to 2004-5. The trend equations obtained and used are given in the appendix. We used these values in equation 8 and predicted tourist arrival for the years 2011-12 to 2029-30.
Next, in step 2, we defined income from trade, hotel and restaurants as a function of total number of tourists and using data for an earlier time period, we estimated the following equation (the estimated values are shown in appendix):

$$Income\_trade\_hotel\_restaurant = \alpha_0 + \alpha_1 tourist\_arrivals \qquad (9)$$

We use the estimated coefficients of equation 9 and predicted values of tourist arrival from equation 7 to predict future income from tourism for the year 2011-12 to 2029-30. The tourism income predicted for this REFSEN scenario is presented below in table 4.2. To recapitulate, the REFSEN is not a 'Business-as- usual' scenario. It incorporates the impacts of policy changes planned by the government.

4.2 Sustainable Development Scenario (SUSSEN)

Under this scenario, we make the following assumptions:

- Ensure that hydel power development does not result in any conversion or loss of land in "protected areas". These areas are 'no-go' areas as they protect the rich floral and faunal biodiversity of the country
- Keep industrial pollution in check, if necessary by limiting industrial production

The SUSSEN we envisage takes into account the two steps outlined above. Hydel power production which impacts protected areas is given up. From the model set up in Section 3 and 4, a reduction in power availability will impact industrial production. The reduction in power generation will also have a marginal impact on facilities for tourists, though accessibility through road connectivity is the more significant variable in determining tourist arrivals. Further, the increase in dense forests due to protection of pristine areas attracts more tourists, as per evidence from district level past data. On balance, the forests connectivity, tourism interaction results in an increase in State Domestic Product from tourism.

The indicator of sustainable sectoral domestic product or income under the sustainable development scenario, referred to as SUSSEN is found as indicated below:

Value added from industries in SUSSEN= Value Added in REFSEN – Value Added lost due to lower power output (a cost to protect PAs)

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[9] See Appendix for complete results on equations 7 and 8.

Value Added from tourism in SUSSEN = Value Added in REFSEN – Value Added from tourism lost due to commercial power reduction + Value added gain due to better tourism income from preserving forests and PAs + Annual Value of non-monetary benefit from FESS.[10]

In estimating the sectoral outputs from the power dependent sectors in the SUSSEN scenario we estimate the effect of abandoning Koldam and Renuka projects, *which together are responsible for 840 MW out of a total planned capacity of about 15000 MW but are in category (1) above.*

- Decreased output of industry is calculated on the assumption that 54% of the reduced output of power following capacity reduction of 840 MW impacts industrial output. The elasticity of industrial output with respect to power availability is taken as 0.631 as estimated in earlier sections (Equation 6).
- Likewise, for impact on tourism value added, we assume that closing Renuka and Koldam will increase protection to sanctuaries and national parks and result in increased tourist arrivals and consequently a rise in tourism output under SUSSEN.[11]The estimated coefficients of equation 7 and 8 are used to measure the impacts.

As shown in table 4.2, the industry sector would be losing some output and the tourism sector would be gaining some output in the SUSSEN scenario or if the state adopts an environmentally sustainable growth path. The details of calculations to measure the specific impacts are given in the appendix and the table 4.3 below gives the estimates of the gain and loss due to the closure of the two power plants.

Table 4.2 Predicted Value Added of Industry and Tourism sectors under REFSEN and SUSDEV Scenarios

	Industry Sector		Tourism Sector	
Year	Fitted manufacturing and construction sector output (Rs lakhs) under REFSEN	Fitted manufacturing and construction sector output (Rs lakhs) under SUSDEV	Fitted income from tourism (Rs lakhs) under REFSEN	Fitted income from tourism (Rs lakhs) under SUSDEV
2012	325232.78	304933.05	113224.35	115284.14
2013	339020.52	318613.05	117298.50	119358.29
2014	352924.34	332409.76	121372.64	123432.44
2015	366942.67	346321.65	125446.79	127506.58
2016	381073.98	360347.18	129520.94	131580.73
2017	395316.71	374484.84	133595.08	135654.87
2018	409669.38	388733.15	137669.23	139729.02
2019	424130.49	403090.63	141743.37	143803.16

[10] Revenue from Forest Ecosystem Services is added to tourism sector as we have not taken into account the forestry sector in the analysis.
[11] From the equations and elasticities estimated in section 4, the increase in tourist arrivals will be of 4.64 lakhs and the increase in SDP through this tourist inflow will be of Rs5110.923 lakhs annually.

2020	438698.61	417555.85	145817.52	147877.31
2021	453372.31	432127.39	149891.66	151951.46
2022	468150.21	446803.87	153965.81	156025.60
2023	483030.95	461583.96	158039.96	160099.75
2024	498013.23	476466.31	162114.10	164173.89
2025	513095.75	491449.65	166188.25	168248.04
2026	528277.25	506532.72	170262.39	172322.18
2027	543556.51	521714.30	174336.54	176396.33
2028	558932.34	536993.17	178410.68	180470.47
2029	574403.57	552368.17	182484.83	184544.62
2030	589969.06	567838.17	186558.98	188618.77

Table 4.3: Net Impact of closure of Renuka and Koeldam Project on Industry and Tourism sector of Himachal Pradesh (Rs lakhs)

Year	Loss in industry	Gain in tourism	Gain in ESS	Net loss	Projected REFSEN Net State Domestic Product[12]	Loss percentage
2012	20299.73	2059.79	13325.5	4914.44	1072508.27	0.004582
2013	20407.47	2059.79	13325.5	5022.18	1110993.48	0.004520
2014	20514.58	2059.79	13325.5	5129.29	1150330.09	0.004459
2015	20621.03	2059.79	13325.5	5235.74	1190123.95	0.004399
2016	20726.80	2059.79	13325.5	5341.51	1230622.53	0.004340
2017	20831.87	2059.79	13325.5	5446.58	1280433.76	0.004254
2018	20936.23	2059.79	13325.5	5550.94	1313896.69	0.004225
2019	21039.86	2059.79	13325.5	5654.57	1356964.97	0.004167
2020	21142.76	2059.79	13325.5	5757.47	1400715.01	0.004110
2021	21244.92	2059.79	13325.5	5859.63	1445815.22	0.004053
2022	21346.33	2059.79	13325.5	5961.04	1498684.11	0.003978
2023	21447.00	2059.79	13325.5	6061.71	1531828.36	0.003957
2024	21546.92	2059.79	13325.5	6161.63	1565079.79	0.003937
2025	21646.09	2059.79	13325.5	6260.80	1598436.48	0.003917
2026	21744.52	2059.79	13325.5	6359.23	1631896.58	0.003897
2027	21842.21	2059.79	13325.5	6456.92	1665458.29	0.003877
2028	21939.17	2059.79	13325.5	6553.88	1699119.91	0.003857
2029	22035.39	2059.79	13325.5	6650.10	1732879.79	0.003838
2030	22130.89	2059.79	13325.5	6745.60	1766736.39	0.003818

The SUSSEN scenario estimates show the consequences of sustainable development while examining inter sectoral linkages. We ensure that protected areas are not eroded into and appropriate payments are made for ecosystem services lost in protected forest areas. It imposes some cost on the economy by reducing the output of industry sector that constitutes some amount like 0.0045% in 2012 to 0.0038% in 2030 of the state net domestic product projected for the REFSEN scenario for Himachal Pradesh.

5. Discussion

[12] We use these figures from the report submitted to the office of the World bank, New Delhi, "India Environment Outlook: Opportunities for growth in the ecologically fragile hill states: a study of Himachal Pradesh".

The scenarios developed in earlier sections illustrate clearly that 'business-as usual' will be at an environmental cost which will increasingly cut into the natural capital base of the state. However, we find that it is possible to develop linkages across different types of activities and that can contribute toward more holistic approaches to sustainable development, though it imposes some amount of cost. The paper tried to estimate the inter-sectoral linkages between industry, hydro power generation and tourism sectors and the cost of pursuing a more environmentally sustainable growth path assuming that the hydro power generation, the main development strategy of the state of Himachal Pradesh, imposes less stress on fragile environmental resources. The cost varies from Rs49.14 million in 2012 to Rs67.15 million in 2030 that constitutes a meagre 0.0045% in 2012 to 0.0038% in 2030 of the projected net state domestic product of the state. There is significant synergy between the preservation of ecologically sensitive areas and tourism and it can be utilised more efficiently to reduce the cost of going green further. Moreover, the paper assumes the preservation benefits to be same over the years which may not be the case. With development and economic well being, the demand for recreation and natural environment increases and the preservation values increase much faster than the benefits from developmental uses. The ecosystem services benefit the people from lower economic strata and thus preserving the ecosystem makes the society more equitable. Incorporating such concerns in the cost benefit analysis will make the estimated cost of pursuing a sustainable growth path much less.

Finally a few words on the institutions and policies in the state from the perspective of 'green growth'.

The Government of Himachal Pradesh has in recent years undertaken a series of initiatives designed to address environmental concerns such as:

- The establishment of a Directorate of Environment,
- Broadening the scope of the State Pollution Control Board's regulatory roles
- Establishing a Special Area Development Authority for carrying out approved development plans and
- Commitments to make Himachal Pradesh a carbon-free state.

However, these initiatives have little, if any, impact on the quantitatively focused growth oriented development thinking which drives the mainstream of development in the state. The overarching vision and mission of Himachal Pradesh for the Eleventh Five Year Plan is to accelerate the actualization of its hydro power potential of about 20,000 MW. Such actualization would have the following twin benefits:

(a) The country would gain in ameliorating shortages in this critical infrastructure sector, through enhanced production of "green energy".
(b) The State's financial resources would be augmented in such manner that its financial dependence on central resources would diminish.

The above statement in the Approach Paper to the Eleventh Plan clearly links hydel power development to the augmentation of the financial resources of the state. The approach paper does not refer to any cross check to confirm whether such an approach would be in accordance with the professed concern of the state government for environment and ecology as expressed by it in the new institutional initiatives mentioned above. There is evidently a communication and vision gap between different segments of the state government which needs to be bridged urgently. This requires a re-look at the structures of planning and implementation.

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DATA SOURCES

Data on Industries

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Data on Forest cover

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http://hpforest.nic.in/himachalforests2008.pdf (Accessed on 3rd June 2009)

Data on Hydro power situation

http://hpplanning.nic.in/Power%20Generation%20and%20Consumption%20%20in%20Himachal%20Pradesh.pdf (data on power situation in Himachal Pradesh, accessed on15th June 2009)

APPENDIX

1. Table A1

Protected Areas in Himachal Pradesh

S.No.	Name of Sanctuary/ National Park/Game Reserve	Name of District	Name of Forest Division	Area (sq km)
Sanctuaries				
1	Shri Naina Devi	Bilaspur	Bilaspur	123
2	Govind Sagar	Bilaspur	Bilaspur	100
3	Gamgul-Siyabehi	Chamba	Chamba	109
4	Kalatop-khajiar	Chamba	Dalhousie	69
5	Kugti	Chamba	Chamba	379
6	Sechu-Tuan Nalla	Chamba	Pangi	103
7	Tundah	Chamba	Dalhousie	64
8	Pong Dam Lake	Kangra	Nurpur/Dehra	307
9	Dhauladhar	Kangra	Dharamshala	944
10	Lippa Asrang	Kinnaur	Pooh	31
11	Rakchham-Chhitkul	Kinnaur	Nichar	304
12	Rupi-Bhaba	Kinnaur	Nichar	503
13	Kanawar	Kullu	Kullu	61
14	Khokhan	Kullu	Kullu	14

15	Kias	Kullu	Kullu	14
16	Manali	Kullu	Kullu	32
17	Tirthan	Kullu	Seraj	61
18	Kibber	Lahul- Spiti	Spiti	1400
19	Bandli	Mandi	Suket	41
20	Nargu	Mandi	Mandi	278
21	Shikar Devi	Mandi	Suket/Nachan	72
22	Daranghati I & II	Shimla	Kotgarh	167
23	Shimla Water Catchment Area	Shimla	M.C. Shimla	10
24	Talra	Shimla	Rohroo/ Chopal	40
25	Renuka	Sirmour	Rajgarh	4
26	Simbalwara	Sirmour	Nahan	19
27	Chail	Solan	Solan	109
28	Darlaghat	Solan	Kunihar	6
29	Majathal	Solan	Kunihar	40
30	Shilli	Solan	Solan	2
31	Sainj	Kullu	-	90
32	Churdhar	Sirmour/ Shimla	Renuka/Chopal	66
Total Sanctuary Area				**5562**
National Parks				
1	Great Himalayan National Park(Shamshi) kullu	Kullu	Parbati	765
2.	Pin Vally National Park,Kaza	Lahul-Spiti	Spiti	675
Total National Park Area				**1440**
Grand Total (Total Protected Area Network)				**7002**

(Source: http://hpforest.nic.in/wsanct2.htm)

2. Estimation of Industrial Production function

Fiscal and Infrastructural incentives to Industrial Sector is being provided by state government to improve industrial climate. Fiscal incentives announced in 2003 and available till 2009 has attracted high investment in the state and has reversed the trend in industrial investment that was static with minor marginal increases in between 1998 and 2003. The hydro power initiatives in the state also assured uninterrupted power supply. We estimated a Cobb-Douglas production function and using the estimated parameters and the predicted inputs (labour employment, power and industrial investment), future industrial value added was predicted.

Production function: $Y_t = AE_t^{\alpha} I_{t-i}^{\beta} P_t^{\gamma}$, *(1)*

Where Y is industrial value added for manufacturing and construction sector (more than 50% is industrial value added), E is industrial employment, I is industrial investment, P is power used, and t is time (1990 to 2005). We restricted our data to this period as input information could not be arranged, especially for industrial power used, either for pre 1990 or post 2005 years. This time series data showed serious multicollinearity problem and we transformed the variables by dividing both the sides by employment (Goldar, 1997) to ease multicollinearity and got the following equation.

$$\ln(\frac{Y_t}{E_t}) = \ln A + (\alpha + \beta + \gamma - 1)\ln E_t + \beta \ln(\frac{I_{t-1}}{E_t}) + \gamma \ln(\frac{P_t}{E_t}) \quad \textit{(2)}$$

$$\ln(\frac{Y_t}{E_t}) = -7.41103 + 0.8138\ln(E_t) + 0.1347\ln(\frac{I_{t-1}}{E_t}) + 0.3317\ln(\frac{P_t}{E_t}) \quad \textit{(3)}$$

(2.25) (3.64) (2.71) (1.71)

n = 15, F (3,11) = 248.22, P = 0.00, Adj R^2 *=0.98*

Using these values in equation 2, we calculated the input coefficients and got the following production function:

$$Y_t = 0.0006 + L_t^{1.347} I_{t-1}^{0.134} P_t^{0.332} \quad (4)$$

Though multicollinearity could be controlled, and there was no heteroschadasticity problem in equation 5, the result still looked unreliable as labour seemed to be getting increasing returns to scale and the coefficient of power was insignificant. We re-estimated the equation dropping the intercept as it was nearly zero and got the following result with all coefficients significant.

$$\ln(\frac{Y_t}{E_t}) = 0.3192\ln(E_t) + 0.1482\ln(\frac{I_{t-1}}{E_t}) + 0.631\ln(\frac{P_t}{E_t}) \quad (5)$$

(6.56) (2.59) (3.87)

n = 15, F (3. 11) = 203.21, P = 0.00, *Adj* R^2 *=0.98*

The corresponding production function is

$$Y_t = L_t^{0.54} I_{t-1}^{0.148} P_t^{0.631} \quad (6)$$

Equation 7 has been used to predict the future value added for manufacturing and construction sector by using fitted values of employment, power and lagged investment in this equation. Trend equation used for employment, investment and power used are the following:

Employment: *E = 95467.23 + 5015.87T* (7)
(150.24) (71.77)
R bar sq = 0.99, n = 15

Investment: *I = 159.117+237.729T* (8)
(0.92) (12.45)
R bar sq = 0.92, n = 15

Industrial Power: $P = 337.654 + 72.926T$ (10)

$(9.51) \quad (18.68)$

$\bar{R}$ *R bar sq = 0.96, n = 15*

2.1 Projected Manufacturing and construction Output

Table A2

Fitted values of Employment, Investment, Power used in Industrial Sector and Fitted Industrial Output with the help of Cobb Douglas Prod Function

Year	Predicted employment	Predicted investment	Predicted investment lag	Predicted power	Predicted manufacturing, Construction output
2012	210832.24	5626.907	5389.177	2015.04	325232.78
2013	215848.11	5864.637	5626.907	2087.97	339020.52
2014	220863.98	6102.367	5864.637	2160.9	352924.34
2015	225879.85	6340.097	6102.367	2233.83	366942.67
2016	230895.72	6577.827	6340.097	2306.76	381073.98
2017	235911.59	6815.557	6577.827	2379.69	395316.71
2018	240927.46	7053.287	6815.557	2452.62	409669.38
2019	245943.33	7291.017	7053.287	2525.55	424130.49
2020	250959.2	7528.747	7291.017	2598.48	438698.61
2021	255975.07	7766.477	7528.747	2671.41	453372.31
2022	260990.94	8004.207	7766.477	2744.34	468150.21
2023	266006.81	8241.937	8004.207	2817.27	483030.95
2024	271022.68	8479.667	8241.937	2890.2	498013.23
2025	276038.55	8717.397	8479.667	2963.13	513095.75
2026	281054.42	8955.127	8717.397	3036.06	528277.25
2027	286070.29	9192.857	8955.127	3108.99	543556.51
2028	291086.16	9430.587	9192.857	3181.92	558932.34
2029	296102.03	9668.317	9430.587	3254.85	574403.57
2030	301117.9	9906.047	9668.317	3327.78	589969.06

3. Tourism

Estimated equation for the entire state (19 years):

$TA = -23.059 + 0.094\ C\_Pow\_used + 0.0032\ Road\_km - 0.0012\ D\_forest\_area$ (11)

$(0.90) \quad (1.47) \quad (3.73) \quad (0.55)$

R bar sq = 0.96, n = 19, F (3, 15) = 144.00, P = 0.00

Where, TA is total tourist arrival, C_Pow_used is commercial power used, (1.99) Road_km is total kilometer of road, and D_forest_are is area under dense forest

Estimated equation for district level pooled data (7 years, 84 observations)

TA = -4767.82 + 461.18 D_forest_area + 65.37 Road_km +
(0.02) (1.96) (2.08)

221084.1 N_S_NP_NATP – 17552.1 Religious_places *(12)*
(1.99) (0.36)

where, TA is tourist arrival in a district,
D_forest_area is total area under dense forest in the district,
Road_km is total kilometers of road network in the district,
N_S_NP_NATP is the number of sanctuaries, national parks and nature parks, and
Religious_places is the total number of religious places (belonging to different religions) falling under a district. This equation is used in SUSDEV scenario discussed next.
Equation 11 is used to predict the tourist arrival in the state in future by using the trend values of the explanatory variables which are obtained from the following (n = 19 for all) equations:

Dense Forest Area: DA = 9632.42 – 37.505 T (13)
(36.36) (-1.62)

Road Kilometre: Road_K = 13197.07 + 842.43 T (14)
(18.62) (13.27)

Commercial Power used: C_Power_use = 51.137 + 10.869 T (15)
(12.03) (29.16)
Income from Trade, Hotel and Restaurant sector was defined to be a function of total tourist arrival in the state and using data for the period 1989-90 to 2003-04, we got the following result:

Income_trade_hotel_resta = 9934.23 + 1099.326 tourist_arrival (16)
(1.53) (6.72)

n = 14, F (1, 12) = 45.19, P = 0.00, Adj R sq = 0.77

Equation 16 and predicted tourist arrival was used to estimate future income to the state from tourism industry.

Table A3
Tourist Arrivals and Tourism Income Predictions

Year	Predicted road km	Predicted Dense forest area (sq km)	Predicted Commercial power use (million kwh)	Predicted tourist arrival (lakhs)	Predicted Income from tourism (Rs lakhs)
2012	31334.53	8807.31	290.2748	93.96	113224.35
2013	32158.96	8769.805	301.1447	97.66	117298.50
2014	32983.39	8732.3	312.0146	101.37	121372.64
2015	33807.82	8694.795	322.8845	105.08	125446.79
2016	34632.25	8657.29	333.7544	108.78	129520.94

2017	35456.68	8619.785	344.6243	112.49	133595.08
2018	36281.11	8582.28	355.4942	116.19	137669.23
2019	37105.54	8544.775	366.3641	119.90	141743.37
2020	37929.97	8507.27	377.234	123.61	145817.52
2021	38754.4	8469.765	388.1039	127.31	149891.66
2022	39578.83	8432.26	398.9738	131.02	153965.81
2023	40403.26	8394.755	409.8437	134.72	158039.96
2024	41227.69	8357.25	420.7136	138.43	162114.10
2025	42052.12	8319.745	431.5835	142.14	166188.25
2026	42876.55	8282.24	442.4534	145.84	170262.39
2027	43700.98	8244.735	453.3233	149.55	174336.54
2028	44525.41	8207.23	464.1932	153.25	178410.68
2029	45349.84	8169.725	475.0631	156.96	182484.83
2030	46174.27	8132.22	485.933	160.67	186558.98

4. Adjustment to measure impact of power on industry and tourism sector

(1MW supplies 43, 00, 000 kwh of power annually)

Renuka is under HPSEB and the power generation belongs to state of Himachal. Koldam project is a public sector concern under NTPC and the state of himachal has right over 12.5% of the power generated, i.e. 800*0.125 = 100MW. Hence closure of Renuka and Koldam will lead to reduced supply of 140MW or 602 million kwh supply of power per annum (assume 50% load factor or 1MW supplies 4, 300, 000 kwh of power annually)

Reduced supply to industries = 140*4300000*0.65*0.50= 195.65 million kwh per annum

Reduced supply to tourism = 140*4300000*0.65*0.075 = 29.35 million kwh per annum

Loss of tourist arrival due to less commercial power from 2011-12 is only 2.76 lakhs of tourists and gain in tourist arrival being 4.64 lakhs due to increase in dense forest area and number of natural parks etc, we have a net gain in tourist arrival by 1.87 lakhs by closing the two projects. Gain in tourism sector income is 2059.79 lakhs of rupees per annum.

Gain in ecosystem services from 4636.8 ha (Renuka 220.8 ha and Koeldam 4416 ha) of forest recovery is Rs13325.5 lakhs per annum (ESS from protected areas is assumed to be 5 times higher than that of normal forest)